

METHOD AND DEVICE FOR TRANSMITTING AND IDENTIFYING A
MODULATION TYPE IN DIGITAL COMMUNICATION SYSTEMS BY WAY OF A
5 PHASE ROTATION FACTOR APPLIED TO A TRAINING SEQUENCE

Cross-Reference to Related Application:

This application is a continuation of copending International
Application No. PCT/DE02/01623, filed May 6, 2002, which
10 designated the United States and which was not published in
English.

Background of the Invention:

Field of the Invention:

15 The invention lies in the field of communications. More
specifically, the present invention relates in general to
digital communications systems, in particular to mobile radio
systems. Yet more specifically, the invention relates in
particular to a transmission and reception method and to a
20 receiver in a digital telecommunications system.

The EDGE (Enhanced Data Rates for GSM Evolution) and the
associated packet service EGPRS (Enhanced GPRS) have been
defined as a transitional standard between the GSM/GPRS and
25 UMTS mobile radio standards. Both GMSK modulation and 8-PSK
modulation are used in the EDGE standard. GMSK modulation uses

a signal area with the signal points +1 and -1, while 8-PSK modulation uses a signal area with eight signal points. If the modulation type to be used for the information transmission between a transmitter and a receiver is not predetermined in a fixed manner, then the receiver must be informed of the modulation type which is being used.

Published international PCT application WO 00/10301 and its counterpart U.S. Patent US 6,473,506 B1, which are hereby incorporated by reference, describe a method for transmission and identification of the modulation type in digital communication systems. The process makes use of the training sequence which is included in a data burst. Each data burst comprises a fixed predetermined training sequence comprising a sequence of data symbols which is known to the receiver and which is used for channel estimation purposes in the receiver. The prior publication proposes that every feasible modulation type be identified by a specific phase rotation factor, and that the training sequence have a phase rotation factor applied to it, that is to say that the data symbols contained in it be rotated using the phase rotation factor. The same phase rotation factor as that which is also used for the modulation of the payload data is preferably used in that case. As is known, GMSK and 8-PSK modulation are distinguished by using different symbol rotation. While GMSK modulation rotates each transmission symbol onwards through 90 degrees,

8-PSK modulation carries out a rotation of 67.5 degrees per transmission symbol. The data symbols in the transmitted training sequence which have been rotated in phase in this way can be used in the receiver in such a way that, at the start
5 of each data burst, the received training sequence in a number of data paths is rotated back through a corresponding number of phase rotation factors. In the quoted example of the two modulation types GMSK and 8-PSK modulation, the received training sequence is thus rotated back through 90 degrees and
10 67.5 degrees, respectively. After this, the received and derotated training sequence is compared with a training sequence to which a channel filter function obtained from a channel estimation process has been applied. The comparison is carried out by subtraction of these training sequences from one
15 another, by addition of the squares of the differences, and by detection of the minimum.

This method has the disadvantage that a channel estimation process must be carried out in each of the data paths which
20 are provided for derotation using the various phase rotation factors, and the comparison with the received and respectively derotated training sequence cannot be carried out until the completion of the channel estimation process and the application to the original training sequence of the channel
25 parameters by means of the channel filter function which has

been mentioned. The method is very complex and requires a large number of circuit units in the receiver.

Summary of the Invention:

5 It is accordingly an object of the invention to provide a method and device for transmitting and identifying the modulation type in digital communication systems by way of a phase rotation factor that is applied to the training sequence, which overcomes the above-mentioned disadvantages of
10 the heretofore-known devices and methods of this general type and which reduce the complexity for detection of the modulation type in receivers in digital communications systems.

15 With the foregoing and other objects in view there is provided, in accordance with the invention, a transmission and reception method in a digital telecommunications system, which comprises:

at a transmitter end, rotating each data symbol in a
20 predetermined initial sequence known to a receiver, in particular a training sequence of a data burst, through a phase rotation factor specific for a type of modulation being used;

at a receiver end, derotating the data symbols through different phase rotation factors to generate a derotated sequence; and

forming a single correlation function between the derotated
5 sequence and the initial sequence based on an assumed temporal position of the initial sequence contained in the received signal for each phase rotation factor;

forming a summation of products between the derotated sequence and the initial sequence for individual moments in time from
10 the correlation function, and squaring a magnitude of the summation to form squares; and

comparing the squares of the magnitudes and determining therefrom a modulation type used at the transmitter end.

15 In accordance with an added feature of the invention, the correlation function between the received sequences and the initial sequence is formed with the initial sequence in an original, unfiltered state.

20 With the above and other objects in view there is also provided, in accordance with the invention, a receiver for a digital telecommunications system, comprising:

means for receiving a data signal from a transmitter and containing an initial sequence known to the receiver and having each data symbol rotated through a phase rotation factor;

- 5 means connected to the receiving means for derotating the data symbols in the received initial sequence through different phase rotation factors;

means for forming a single correlation function between the sequence obtained by the derotating means and the initial
10 sequence on the basis of an assumed temporal position of the initial sequence contained in the received signal for each phase rotation factor;

means for forming a summation of products between the sequence obtained by the derotating means and the initial sequence for
15 individual moments in time;

means for squaring a magnitude of a summation for forming squares; and

means for determining a maximum of the squares formed in the squaring means and determining therefrom a modulation type
20 used at the transmitter.

The invention is primarily based on the significant knowledge that it is not absolutely essential to carry out a channel estimation process in every data path in the receiver in which derotation of the received training sequence is carried out.

5 The invention deliberately avoids channel estimation in this early stage of detection of the modulation type. Instead of this, every received and derotated training sequence is compared directly with the original, unfiltered training sequence. The comparison is carried out via a correlation
10 process, that is to say by multiplying the two training sequences with one another. After this, the modulation type is determined by which phase rotation factor reaches a maximum in the respective data path during the derotation and the subsequent correlation processes.

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In this case, the invention is not restricted to using the training sequence, which is normally included in a data burst, in the described manner. In principle, it is also possible to use any other sequence of information data that is transmitted
20 in any case during the communication process in the manner according to the invention, in order to transmit information about the modulation type.

In contrast with WO 00/10301 and US 6,473,506 B1, the present
25 invention does not require any channel estimation processes for detection of the modulation type, since a correlation is

carried out between the received and derotated training sequence and the original, unfiltered training sequence. The original training sequence is therefore not subjected to any channel filter function before the correlation step is carried out. According to the invention only a number of data paths are therefore provided in the receiver, in each of which derotations of the received training sequence through predetermined phase rotation factors are carried out, with the derotation process in each data path being followed by a correlation process, in which the received, derotated training sequence is correlated with the original, unfiltered training sequence. Channel estimation is carried out only after the detection of the modulation type.

A further difference to the already mentioned document that forms this generic type is the nature of the mathematical comparison of the training sequences. While, in the case of the cited prior art, the training sequences to be compared are subtracted from one another, a correlation function is formed according to the invention. If the timing of the training sequence within the received data burst is known only with a certain accuracy, it is also possible to provide for the derotation and correlation processes to be carried out two or more times successively in each data path, with the training sequences that have to be multiplied by one another in the correlation step being shifted incrementally in time with

respect to one another, and with the maximum correlation result being determined from these two or more correlation steps.

5 The invention will be explained in more detail in the following text with reference to an exemplary embodiment. The exemplary embodiment relates to the use of the two modulation types GMSK (Gaussian minimum shift keying) and 8-PSK (8-ary phase shift keying).

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GMSK modulation can be approximated by way of amplitude modulation and, in consequence, can be interpreted as follows:

A. A bit b_k ($= 0,1$) which is supplied is mapped onto a symbol
15 a_k ($= +1, -1$) where k denotes a discrete moment in time.

B. The GMSK symbols a_k are rotated using $\pi/2$ radians per symbol:

20
$$s_k = e^{jk\pi/2} a_k = j^k a_k \quad (1)$$

C. The rotated GMSK symbols s_k are filtered by means of a pulse filter:

25
$$\tilde{\chi}_k = \sum_{i=0}^L h_i s_{k-i} \quad (2)$$

where $\tilde{\chi}_k$ is the modulated baseband signal, which is mixed with the desired carrier frequency and is then transmitted to the antenna.

5 8-PSK modulation is defined in a similar way. However, this differs from GMSK modulation in the number of bits that are mapped onto one symbol and in the rotation:

A. A group of three bits $\{b_{3k}, b_{3k+1}, b_{3k+2}\}$ which are supplied
10 is mapped onto one 8-PSK symbol

$$a_k = e^{jn\pi/4} \quad (0 \leq n \leq 7).$$

B. The 8-PSK symbols a_k are rotated through $3\pi/8$ radians per
15 symbol:

$$s_k = e^{jk3\pi/8} a_k \quad (3)$$

C. The rotated 8-PSK symbols s_k are filtered using a pulse
20 filter:

$$\tilde{\chi}_k = \sum_{i=0}^L h_i s_{k-i} \quad (4)$$

One 8-PSK data symbol thus contains three times as much
25 information as one GMSK data symbol. 8-PSK modulation is thus

used for high levels of data transmission, while GSK modulation is used for low levels of data transmission.

The EDGE Standard allows both modulation types to be used, and
5 the modulation type to be changed from burst to burst.

Initially, EDGE receivers do not know the modulation type that is used to modulate the data transmitted to them from the transmitter. For each burst, the EDGE receiver identifies only one block of complex-value baseband input data x_k , and must
10 itself decide on the modulation type which is being used. This procedure is thus also referred to as blind modulation detection.

According to the invention, information about the modulation
15 type that is being used is applied to the transmitted signal, for this purpose using the predetermined training sequence, which is known to the receiver and which is included in each GSM/EDGE burst. The data symbols in the training sequence are rotated at the transmitter end using a phase rotation factor
20 which is also used for the modulation of the payload signals, although in principle a different phase rotation factor can also be used for this purpose.

Other features which are considered as characteristic for the
25 invention are set forth in the appended claims.

Although the invention is illustrated and described herein as embodied in a transmission and identification of the modulation type in digital communication systems by means of a phase rotation factor which is applied to the training
5 sequence, it is nevertheless not intended to be limited to the details shown, since various modifications and structural changes may be made therein without departing from the spirit of the invention and within the scope and range of equivalents of the claims.

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The construction and method of operation of the invention, however, together with additional objects and advantages thereof will be best understood from the following description of specific embodiments when read in connection with the
15 accompanying drawing.

Brief Description of the Drawing:

The single drawing figure is a schematic illustration of an exemplary embodiment for the method according to the invention
20 for blind modulation detection.

Description of the Preferred Embodiments:

Referring now to the sole figure of the drawing in detail, there is shown a flowchart for blind modulation detection in a
25 receiver. A received training sequence $\tilde{\chi}_k$ is used to produce two samples, which are fed into two data paths corresponding

to the two modulation types. In the figure, $\tilde{\chi}_k$ ($k = 1, 2, \dots, N$) denotes the received training sequence. N denotes the length of the training sequence and t_k ($k = 1, 2, \dots, N$) denotes the original training sequence, which is stored in the receiver.

First of all, the received training sequence $\tilde{\chi}_k$ is derotated in the data paths through $-\pi/2$ per symbol for GMSK and through $-3\pi/8$ per symbol for 8-PSK.

After derotation, the received and respectively derotated training sequence y_k is correlated with the original training sequence t_k . Since the correlation may be complex numbers since the phase of the signal is unknown, the square of the magnitude of the correlation is calculated after summation of the products for the individual moments in time k .

Finally, the correlation result between GMSK and 8-PSK is compared. If the received, derotated training sequence y_k^{GMSK} is more similar to the original training sequence t_k than the received and derotated training sequence y_k^{8PSK} , that is to say $c^{\text{GMSK}} > c^{\text{8PSK}}$, this results in the detection conclusion that the corresponding data burst is modulated using the modulation type GMSK. Otherwise, the detection process indicates that the modulation time is 8-PSK.

After this blind modulation detection, the demodulator can then start the channel estimation process.

- 5 Owing to the fact that uncertainties in the timing of the received training sequence may exist within the data burst, it is possible to provide for the correlation process to be carried out two or more times successively in each data path, by the training sequences to be correlated with one another
- 10 being shifted in time with respect to one another. It is thus possible first of all to carry out a first correlation process in each data path on the basis of specific assumptions about the timing of the training sequence.
- 15 The data symbols in the sequences t_k and y_k to be correlated can then be passed once again to the correlator, with a slight offset with respect to one another. The maximum of two or more correlation processes carried out in this way is then chosen.
- 20 The method according to the invention for automatic identification of the modulation type which is being used is distinguished by a high hit confidence, with less complexity than the prior art.